Environmental Pollution and Income as a Measure of Economic Growth in Malaysia

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Abstract

It is possible to distinguish three main channels whereby income growth affects the quality of the environment as first suggested by Grossman (1995). They are firstly, a scale effect, secondly a composition effect and thirdly, technological progress. A recent research criticism by Cole (2003 and 2004) of the environmental Kuznets curve hypothesis is based on the occurrence of foreign direct investment and international trade. In the previous EKC literature, EKC is always estimated in the form of a single equation. However, according to Shen (2006), since both income and environmental quality are endogenous variables in which they impact upon each other, therefore the estimation of single equation relationships where simultaneity exists will produce biased and inconsistent estimates. The general objective of this study is to measure the relationship between economic growth and different indicators of air pollution in Malaysia. Air pollution indicators were assessed on a number of measures: Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3) and Particulate Matter (PM_{10}). The income level per capita GDP (Gross Domestic Product) were measured from the year 1996 to 2006 quarterly. This study contributes to the available literature by Hung et al (2004) and Shen (2006) by adopting the model and extending it to include variables such as the number of motor vehicles, local labour, and foreign labour, the number of university graduates, foreign direct investment and government spending. Being different from the study by Hung et al (2004) and Shen (2006), this study estimates population density as an endogenous variable. It formulates a four-equation simultaneous model for empirical research. It is testing for exogeneity with the Hausman test and estimating the simultaneity model using the two-stages least squares method. The EKC hypothesis is supported in the cases of SO_2 and PM_{10} and there are several differences found between single polynomial equation estimators commonly used in EKC literatures and simultaneous equation estimators.

Keywords*: Air Pollutants, Economic Growth, Environmental Kuznets Curve, Malaysia*

INTRODUCTION

Income affects pollution and pollution affects income. Estimating the relationship only by a single polynomial equation might probably produce biased and inconsistent estimates since the economic growth and the environmental quality are jointly determined. According to Shen (2006), it is therefore more appropriate to use a simultaneous equation model for the estimation. In this study, based on EKC empirical literatures the first equation (pollution equation) is a commonly used polynomial equation. Contributes to the available literature by Shen (2006), this study adds two extra important variables which are the secondary industry share and the government pollution abatement expense into pollution equation to explain the impacts of industrial structure and environmental policy on pollution in Malaysia. Being different from the study by Shen (2006), this study adds variable such as the number of motor vehicles to explain the impact of it on pollution in Malaysia. This study also estimates population as an endogenous variable being affected by pollution through impacts on health. According to Lopez (1994) and de Bruyn (2000), pollution may directly reduce output and productivity of man-made capital and labor in which it act as a negative externality. To control the feedback impact of pollution on income, the second equation that is income equation is introduced to manipulate the pollutant emission as an input in an extended Cobb–Douglas production function. Due to pollution abatement expense and the emission level are jointly determined, a third equation (abatement equation) is introduced to explain abatement expense. Since adding population density into pollution equation may cause another source of simultaneous error in the model, in which population density and the emission level are also jointly determined, a fourth equation (population density) is also introduced to explain the effects of pollution on population density. This study is consequently to test the significant difference between single polynomial equation estimators and simultaneous equations estimators after the simultaneous equations model is constructed.

LITERATURE REVIEW

Based on the study by Panayotou (1998), relating an environmental impact indicator to a measure of income per capita, empirical models of environment and growth consist usually of reduced form single-equation specifications. Income distribution, population density, institutional variables, openness to trade and geographical are the examples of different studies that control for different variables. In income and environmental degradation, the functional specification is usually quadratic; log quadratic or cubic. A number of critical surveys of the EKC literature have been published about this. The key critism of Mariano et al (1998) hypothesize that more equitable distributions of power tend, ceteris paribus, to result in better environmental quality. Their regression results generally are consistent with this hypothesis. Recent critiques by Kristin (2006) stated that there is no single EKC that fits all pollutants for all places at all times. It seems to work best for local air pollutants such as oxides, nitrogen, sulfur dioxide, and particulate matter. Income growth without institutional matters is not enough. Whether improvements materialize depends on government policies, social institutions and the completeness and functioning of markets need to look for structural explanation of the EKC. The relationship between a number of air and water pollutants in Malaysia and per capita income has been examined by Vincent (1997) from the late 70s to the early 90s. This study emerges from the single-country study and came out with two main conclusions. First, for the income environment relationship in single countries, cross-country analysis may fail to predict. Second, none of the pollutants examined by Vincent shows an inverted-U relationship with income. The effects of the spatial intensity of economic activity and income on the atmospheric concentration of sulfur dioxide have been explored by Robert K. Kaufmann et al (1998). An inverted U-shaped relation between the SO_2 concentrations and spatial intensity of economic activity can be seen from the results. The study also shows that there is a U-shaped relation between atmospheric concentration of SO_2 and income. From this point of view, it suggests that instead of income, the spatial intensity of economic activity provides the impetus for policies and technologies that reduce SO_2 emissions. Based on the study by Stern et al., (1998), Cole (2003 and 2004), Suri and Chapman (1998), Arrow et al (1995) and Rothman (1998), the environmental Kuznets curve hypothesis is based on the occurrence of international trade and foreign direct investment. This is one of the most damaging criticisms of the environmental Kuznets curve hypothesis. According to Anton et al (2005), the argument asserts that the downturn in emissions at higher levels of per capita income can be explained, at least to some extent, by the relocation of "dirty" industries from developed to developing countries, and the tendency among developed countries to import pollution-intensive goods from developing countries rather than produce them at home. As has been shown in the study by Suri and Chapman (1998), per capita energy use rises with per capita income from per capita consumption of pollution-intensive goods. The argument by Rothman (1998), Suri and Chapman (1998), Ekins (1997) and Stern et al (1998), stated that for global environmental impact this is a more appropriate measure.

SOURCES OF DATA

This study has gathered the external information from The Department of Environment (DOE) in Malaysia, Department of Statistics in Malaysia, University library, British Council, National library and Memorial library. Besides, the sources like books, newspapers, journals and internet that are relevant to the research topic are used. To examine the relationship between air pollution and economic growth, the study estimates several equations that relate the level of pollution in a location to a flexible function of the current and GDP per capita in the country and to other covariates. Air pollution indicators were assessed on a number of measures: Carbon Monoxide (CO), Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3) and Suspended Particulate Matter (SPM). The income levels GDP (Gross Domestic Product) per capita were measured from year 1996 to 2006 quarterly.

RESULTS AND DISCUSSIONS

Being different from Shen (2006), this study assumes population density to be as an endogenous variable. A study by Shen (2006) only regarded income per capita and government pollution abatement expenses as endogenous variables. In actual fact, population density is also endogenous to the system, being affected by pollution through impacts on health. Based on the study by Lopez (1994) and de Bruyn (2000), pollution may act as a negative externality by directly reducing productivity of man-made capital and labor and output. The examples are like the corrosion of industrial equipment due to polluted air or water, loss of days worked due to health problems, and product voided because of being polluted. Pollutants that are inhaled have serious impact on human health taken up by the blood and pumped all round the body and affecting the lungs and the respiratory system. The first incident that made people aware of the damage done to the atmosphere due to industrialization was the magnitude of the London fog of 1952, which affected such a large number of people. The SPM levels increased manifold and resulted in over 4000 deaths (www.edugreen.teri.res.in). Therefore, a three simultaneous equations method might produce bias and inconsistent estimates. This study formulates four simultaneous equations model that can be as Equations (1), (2), (3) and (4). To check the statistical significance of the cubic terms of log (per capita GDP) in all the pollutants, a t test has been employed by this study. As can be seen in Table 1 below this study has found that generally all of them are not significantly different from zero even at 10% level except for SO_2. Since the majority of the indicators of air pollutants are insignificant, this study omits the cubic terms in Equation (1).

Table 1: T-test to check the statistical significance of the cubic terms of log (per capita GDP) in all the pollutants (t statistics in parentheses)

	SO_2	PM_{10}	CO	O	NO
Intercept	-3.7206	4.8690	0.6623	-2.2185	-3.6558
(log(per capita GDP))^3	-7.1689	0.7707	0.1503	-0.6655	0.3676
Adjusted R-square	0.2375	0.0054	-0.0236	0.0039	-0.0225

Therefore, this study omit the cubic terms in Equation (1).

$$\log P_{t} = \alpha_0 + \alpha_1 \text{Iog } Y_t + \alpha_2 (\text{Iog}Y_t)^2 + \alpha_3 \log abate_t + \alpha_4 \log ind_t + \alpha_5 \log PD_t + \alpha_6 \log MV + \alpha_7 T_2 + \alpha_8 T_3 + \alpha_9 T_4 + e_t \quad (1)$$

$$\text{Iog } Y_t = \beta_0 + \beta_1 \text{ Iog } P_t + \beta_2 \text{ Iog } LL_t + \beta_3 \text{ Iog } FL_t + \beta_4 \text{ Iog } U_t + \beta_5 \text{ Iog } G_t + \beta_6 \log FDI_t + \beta_7 \log K_t + \beta_8 T_2 + \beta_9 T_3 + \beta_{10} T_4 + €_t \quad (2)$$

$$\log abate_t = \lambda_0 + \lambda_1 \log K_t + \lambda_2 \log ind_t + \lambda_3 \log P_t + \lambda_4 T_2 + \lambda_5 T_3 + \lambda_6 T_4 + \nu_t \quad (3)$$

$$\log PD_t = \pi_0 + \pi_1 \log P + \pi_2 T_2 + \pi_3 T_3 + \pi_4 T_4 + \pm_t \quad (4)$$

Equation (1) represents the pollution equation, where

P_t represents air pollution for year t;

Y_t represents GDP per capita for year t;

T represents seasonal or quarterly dummy variables in which T2, T3 and T4 are dummies for the second, third and fourth quarter of each year taking a value of 1 for the relevant quarter and a value of 0 for the first quarter (Gujarati 2006). These quarterly dummy variables are included in the model in order for this study to capture seasonal effects in Malaysia. The robust estimates of heteroscedasticity are presented in Table 2 to Table 7 as white.

Table 2: Regression Results: Estimated results for air pollutants [Eq. (1)] (t statistics in parentheses)

	Single polynomial equation		Simultaneous equations	
	SO_2	PM_{10}	SO_2	PM_{10}
Intercept	18.21882	15.57414	173.5490	236.0215
log(per capita GDP)	3.0681 (0.2204)	1.1648 (0.1651)	19.8546 (0.7046) White 0.7104	26.326 (1.3796) White -1.7191
(log(per capita GDP))^2	-3.7415 (-0.2536)	-0.7097 (-0.0949)	-27.159 (-0.6346) White -0.9870	-37.3356 (-1.2883) White 2.0665
log(abatement expense)	-0.1101 (-0.6007)	0.0203 (0.2191)	0.1265 (0.1650) White 0.6250	0.3384 (0.6516) White 0.8317
log(secondary industry share)	0.5700 (0.3204)	0.5655 (0.6273)	2.0301 (0.3798) White 1.1930	3.4048 (0.9406) White 1.0077
log(population density)	-5.6719 (-0.2948)	-2.1758 (-0.2232)	-34.403 (-0.4257) White 1.4629	-42.824 (-0.7824) White -0.7754
log (motor	-0.3288	0.7002	15.836	23.742

vehicles)	(-0.0307)	(0.1289)	(0.3515) White -1.6756	(0.7782) White -0.0177
Time trend, T2	0.2618 (1.0621)	0.0815 (0.6522)	0.5336 (0.6369) White -0.7202	0.4703 (0.8289) White -0.4204
Time trend, T3	0.3725 (0.7423)	0.2015 (0.7925)	1.0351 (0.5218) White -0.6732	1.1900 (0.8859) White -0.1105
Time trend, T4	0.2334 (0.3268)	-0.1078 (-0.2978)	1.2237 (0.4210) White -0.5028	1.3680 (0.6950) White -0.0843
Adjusted R-square	0.7256	0.3187	0.6965	-0.3461
Hausman Test for exogeneity (F-statistic)	-	-	10.5153	3.1926
Turning point	0.4100	0.8206	0.3655	0.3526
BG LM test	-	-	0.0197	0.2684
Ramsey Reset test	-	-	0.1280	0.1053
Chow test	-	-	1.0617	0.7213

Table 3: Regression Results: Estimated results for air pollutants [Eq. (1)] (t statistics in parentheses)

	Single polynomial equation		Simultaneous equations	
	CO	O	CO	O
Intercept	229.2427	78.1112	89.1727	229.9870
log(per capita GDP)	-1.9372 (-0.1059)	-1.0508 (-0.1885)	-4.0498 (-0.1058) White -1.0391	10.2251 (0.7561) White -1.7851
(log(per capita GDP))^2	-8.5496 (-0.4408)	-2.7080 (-0.4584)	-3.0078 (-0.0518) White 1.3102	-21.9872 (-1.0705) White 1.8557
log(abatement expense)	0.0833 (0.3458)	0.0540 (0.7364)	-0.3298 (-0.3167) White 4.7703	0.2718 (0.7384) White 0.5084
log(secondary industry share)	5.0573 (2.1622)	2.1743 (3.0515)	4.6453 (0.6400) White 0.1227	4.3354 (1.6901) White 1.0983
log(population density)	-41.5185 (-1.6416)	-14.7214 (-1.9107)	-15.8505 (-0.1444) White -2.4276	-42.4565 (-1.0946) White 3.0461
log (motor vehicles)	21.9925 (1.5601)	7.3372 (1.7085)	8.2269 (0.1345) White 2.0655	23.0138 (1.0644) White -2.1142
Time trend, T2	0.5122 (1.5805)	0.2066 (2.0926)	0.2454 (0.2156) White 3.2121	0.4819 (1.1985) White -0.9785

Time trend, T3	1.1714 (1.7755)	0.3539 (1.7608)	0.5979 (0.2219) White 3.4750	1.0480 (1.1009) White -0.4770
Time trend, T4	1.5047 (1.6026)	0.3730 (1.3042)	0.6695 (0.1696) White 3.6434	1.4002 (1.0037) White -0.3044
Adjusted R-square	0.2332	0.4590	0.0949	0.1406
Hausman Test for exogeneity (F-statistic)	-	-	8.1682	5.1838
Turning point	(0.1133)	(0.1940)	(0.6732)	0.2325
BG LM test	-	-	1.2479	0.2247
Ramsey Reset test	-	-	0.2568	0.0907
Chow test	-	-	1.6422	0.2204

Table 4: Regression Results: Estimated results for air pollutant [Eq. (1)] (t statistics in parentheses)

	Single polynomial equation	Simultaneous equations
	NO	NO
Intercept	32.8991	-386.6431
log(per capita GDP)	10.8362 (0.5999)	51.5974 (1.1944) White 1.1228
(log(per capita GDP))^2	-10.8957 (-0.5691)	-36.4016 (-0.5548) White -1.0011
log(abatement expense)	0.0003 (0.0013)	-0.8706 (-0.7406) White 0.6503
log(secondary industry share)	1.7649 (0.7644)	-3.1568 (-0.3853) White -0.6388
log(population density)	-7.9015 (-0.3165)	66.3549 (0.5355) White -2.8891
log (motor vehicles)	2.2815 (0.1640)	-38.0844 (-0.5514) White 1.9256
Time trend, T2	0.1368 (0.4278)	-0.7079 (-0.5511) White 1.0779
Time trend, T3	0.1930 (0.2964)	-1.7004 (-0.5592) White 0.9469
Time trend, T4	0.2792 (0.3012)	-2.4191 (-0.5429) White 1.1519
Adjusted R-	0.0890	-0.4065

square		
Hausman Test for exogeneity (F-statistic)	-	2.6951
Turning point	0.4972	0.7087
BG LM test	-	0.4665
Ramsey Reset test	-	0.6749
Chow test	-	0.3545

Table 5: Estimated results for income equation [Equation (2)] (t statistics in parentheses)

	log (GDP)	log (GDP)	log (GDP)	log (GDP)	log (GDP)
log SO_2	0.1665 (0.4300) White 0.6091				
log PM_{10}		-0.0035 (-0.0522) White -0.4962			
log CO			0.1170 (1.6174) White 2.6735		
log O				0.0960 (2.5240) White 0.3745	
log NO					-0.0433 (2.2442) White 2.0715
Intercept	-8.7097	-1.0585	-13.7309	-2.6658	0.3399
log(local labor)	-3.7092 (-0.6067) White -0.4454	-1.1328 (-2.7995) White 1.0819	-3.0961 (-2.0512) White -0.6090	-1.3072 (-3.1965) White 1.2882	-0.9811 (-2.0327) White 0.0147
log (foreign labor)	-0.6705 (-0.3887) White -0.6109	0.0661 (0.4884) White 1.6267	-1.0830 (-1.4630) White 1.9912	-0.1456 (-1.1371) White -0.5927	0.2533 (1.7483) White -0.1329
log(physical capital)	0.1595 (1.8919) White -0.7498	0.14033 (3.2036) White -1.1533	0.0799 (1.2488) White -2.1872	0.1106 (4.2214) White -1.3241	0.1819 (5.3082) White -1.3375
log(govt.spending)	0.2078 (2.1629) White 2.8970	0.2164 (6.7489) White 0.0938	0.2577 (3.3672) White -0.2169	0.2248 (6.8695) White 0.7227	0.2302 (5.8810) White -0.5947
log(foreign direct investment)	0.0343 (0.7424) White 0.9480	0.0158 (2.5218) White 0.0196	-0.0159 (-0.6707) White -1.4242	0.0153 (2.5481) White 0.7039	0.0155 (2.1772) White -0.0829
log(university students)	0.3001 (0.5683) White -1.9221	0.0921 (0.9574) White -1.2672	-0.3586 (-1.1457) White 0.6487	0.0172 (0.2390) White -0.6157	0.1490 (1.7904) White -0.2676

Time trend, T2	-0.1056 (-0.7539) White -3.1259	-0.0468 (-3.8813) White -1.3045	-0.0905 (-2.4607) White -1.2830	-0.0588 (-4.8029) White -0.3583	-0.0440 (-3.2579) White -0.7385
Time trend, T3	-0.1326 (-0.6364) White -3.3239	-0.0442 (-2.0541) White -1.4353	-0.1230 (-2.0952) White -1.5365	-0.0565 (-3.5845) White -0.3332	-0.0381 (-2.0978) White -0.3189
Time trend, T4	-0.1259 (-0.7468) White -1.9922	-0.0587 (-2.7525) White -0.6012	-0.1639 (-2.0217) White -1.4887	-0.0632 (-2.8893) White -1.0929	-0.0467 (-1.7673) White -0.0512
Adjusted R-square	0.2372	0.9126	0.5481	0.9081	0.8704
BG LM test	0.1860	0.1046	0.4115	0.1424	0.0555
Ramsey Reset test	1.1305	8.4243	0.5229	12.9410	4.7618
Chow test	4.9258	3.9532	2.0844	2.5135	2.8809

Table 6: Estimated results for abatement equation [Equation (3)] (t statistics in parentheses)

	log (Abatement)	log (Abatement)	log (Abatement)	log (Abatement)	log (Abatemen t)
log SO_2	-2.1672 (-4.3752) White 1.6054				
log PM_{10}		-5.6953 (-2.0520) White 2.8597			
log CO			-1.8312 (-5.1158) White 4.6606		
log O				-5.2975 (-4.5760) White 3.805269	
log NO					-1.9913 (2.8929) White 5.7020
Intercept	-13.2840	28.1693	0.1702	-12.9137	-8.0141
log(secondary industry share)	-4.4877 (-2.0410) White -1.5625	5.4729 (2.8292) White -0.0427	3.0997 (2.5090) White -0.5469	2.8605 (2.3037) White 1.7565	3.0445 (2.0240) White -0.8013
log(physical capital)	2.4428 (3.0088) White -3.0953	0.8640 (0.9209) White 0.7278	0.3845 (0.6372) White -1.5979	1.0052 (1.5703) White -0.9415	1.4035 (1.5936) White 0.8178
Time trend, T2	0.5274 (1.3207) White -1.6642	0.25144 (0.4477) White 0.3644	0.1282 (0.3357) White 0.2112	0.3201 (0.8155) White -0.9596	0.1031 (0.2207) White 0.6877
Time trend, T3	0.8428 (1.9055) White -2.1349	0.9177 (1.1932) White 0.1197	0.2468 (0.6325) White -0.1949	0.0462 (0.1205) White -1.0071	0.1816 (0.3774) White 0.4654

Time trend, T4	0.67423 (1.5891) White 0.2104	-0.8494 (-1.4257) White -0.8264	0.0252 (0.0659) White 0.0185	-0.6365 (-1.6465) White -0.7330	0.3464 (0.6872) White 0.2651
Adjusted R-square	0.1058	-0.8221	0.0476	0.0481	-0.3981
BG LM test	0.4139	1.4934	1.7655	0.4095	1.01840
Ramsey Reset test	0.5831	1.1608	0.0474	1.5456	0.5521
Chow test	4.6841	0.2163	-1.3163	-0.2331	0.3579

Table 7: Estimated results for population density equation [Equation (4)] (t statistics in parentheses)

	log (pop.density)	log (pop.density)	log (pop.density)	log (pop.density)	log (pop.density)
log SO_2	-0.1395 (-11.3588) White 2.1207				
log PM_{10}		0.0391 (0.2569) White 1.6401			
log CO			-0.0766 (-2.3331) White -1.8140		
log O				-0.3516 (-3.6414) White 2.6231	
log NO					-0.1395 (-3.0737) White 6.3473
Intercept	3.6181	4.0784	4.3106	3.4577	3.7401
Time trend, T2	0.0410 (2.1851) White -0.3802	0.0013 (0.0331) White 0.1732	0.0188 (0.5413) White -0.2981	0.0426 (1.2270) White -0.8311	0.0327 (0.8827) White 0.6251
Time trend, T3	0.0571 (3.0121) White -0.6713	0.0017 (0.0331) White -0.4577	0.0310 (0.8780) White -0.0850	0.0310 (0.9225) White -0.8783	0.0442 (1.1749) White 0.4021
Time trend, T4	0.0383 (2.0587) White 1.097117	0.0197 (0.5276) White 0.1649	0.0267 (0.7749) White -0.3847	-0.0129 (-0.3790) White -1.6045	0.0547 (1.4352) White -0.4341
Adjusted R-square	0.6939	-0.0977	-0.0460	0.0189	-0.1575
BG LM test	0.0984	85.207	18.1045	4.0038	3.3283
Ramsey Reset test	2.2359	7.9721	12.4543	8.9559	1.0074
Chow test	1.0947	18.4351	19.5461	13.9604	12.8074

Some indicators of pollutants showing that heteroscedasticity found in the error terms for some of the variables in the model do not have a constant variance. A White test is significant at 5% level of significance for some of the pollutant indicators. Due to only minor indicators showing significantly at 5% level of significance, this study can procede without dropping any of the variables. Breusch-Godfrey Serial Correlation LM test has been used by this study in order to test the error terms which are not correlated with each other. Autocorrelation are found in air pollutant equation for CO, NO_2 and income equations for CO and CO, NO_2, PM_{10}, in abatement equation. Autocorrelation are also found in population density equation. To check whether this model suffers with autocorrelation due to specification error, this study proceeds with the Ramsey Reset test. The result in Table 2 to Table 7 shows that all the indicators of pollutants in pollutant equation do not suffer with specification error, where as O, NO_2, PM_{10} in income equation, and CO, O, PM_{10} in population density equation suffer with specification error which means that this study omit certain relevant variables. Due to this study taking five measures of indicators of pollutants and 30% from the measures showing specification error, this study can conclude that this model is not suffering from specification error problems. Therefore, this study can continue without adding any other relevant variables. Then, to check parameter instability of the model, this study use Chow test to determine the existence of structural break. Table 2 to Table 7 shows that only SO_2, O, NO, PM_{10}, in income equation, and SO_2 in abatement equation and CO, O, PM_{10} in population density equation suffer with structural break. This indicates that the estimated parameters are not stable during the sample period of the first quarter of 1996 to the first quarter of 2002. Parameter instability may happen when there is a structural change in the relationship between dependent and independent variables. This structural change may be due to external forces such as an oil crisis and a financial crisis or due to policy changes such as fixed exchange rate to flexible exchange rate. Malaysia suffers with financial crisis in the year 1996 and 1997. Due to only minor indicators of air and water pollutants suffering with this problem; this study does not break the data into the pre and post period.

This study will also discuss the issue concerning the exogeneity of the log form of per capita Gross Domestic Product, its quadratic term and per capita pollution abatement expense. By referring from Table 2 to Table 4 results of the Hausman test for exogeneity shows that the null hypothesis of exogeneity of these variables are statistically rejected in all cases. This study is referring to the F test as more than one endogenous regressor is involved (Gujarati, 1995). Necessitating the two-stage least square method for estimating the simultaneous equations model, this study suggests that the simultaneous relationship between per capita income and per capita pollutant emission does exist in the dataset of Malaysia. There are some differences found by comparing between the single polynomial equation model estimators and the simultaneous equations model estimators, [some of the interpretation below is following the study by Shen (2006)]:

Single polynomial equation model:

(a) In two pollutants that is CO and O, estimated results suggest that the expected EKCs are not found to exist.

(b) The difference between these two methods is found in the estimated coefficients of several other explanatory variables.

(i) The difference for per capita pollution abatement expense is that its elasticity's in the case of CO on per capita emission in Table 3 is 0.0833 showing that as per capita pollution abatement expense increases by 1 percent per capita emission of CO increases by 0.0833 percent. The same goes to NO as can be seen in Table 4. As per capita pollution abatement expense increases by one percent per capita emission of NO increases by 0.0003. This is not following the theory in which as abatement expenses increases then the pollution emission should decreases.

(ii) As can be seen in Table 3, in the case of CO by using single equation, as abatement expense increases by one percent then CO increases by 0.0833 percent. In the case of NO in Table 4, by using a single equation, as abatement expense increases by one percent NO increases by 0.0003 percent. There is no significant impact of per capita pollution abatement expense on per capita emissions. The policy makers do not have any incentive to invest on pollution abatement in order to reduce pollutant emissions.

(iii) As can be seen in Table 2, by using the single polynomial equation, the turning points, $-\alpha_1/2\alpha_2$ of these inverse-U-shaped curves for SO_2 and PM_{10} are estimated nearly 1.12 times and 5.4.3 times, larger in magnitude. This evidence indicates that if this study estimates the impact of income on pollution directly by a single polynomial equation model and ignores the simultaneous relationship between income and pollution, the turning points would be overestimated. It shows that after the per capita GDP reaches upper level, the per capita emission should be decreased as income increases. These different turning points surely lead to different policy implications in which it shows that the government of Malaysia tightens and stringent the policy implications in a latter stage.

(iv) To investigate industrial structural impact from two sources:

(1) Direct impact measured by the coefficient in Equation (1):

As can be seen from table 4 in the case of NO, the direct impact indicates that a 1% increase in the secondary industry share causes an increase of 0.5700% in per capita emission.

(2) Indirect impact is measured by the coefficient of the secondary industry share in Equation (3) multiplying the coefficient of per capita pollution abatement expense in Equation (1):

In the case of NO, the indirect impact via pollution abatement expense shows that a 1% increase in the secondary industry share causes a decrease of 4.4877% of per capita pollution abatement expense from table 6, and a 1% increase in pollution abatement expense decreases per capita emission by 0.1101% from table 4, therefore there is a decrease of 0.4941 % (4.4877*0.1101) of per capita emission.

(3) Net impact should be calculated as the net values of these two impacts:

In the case of NO, the net impact is that a 1% increase in the secondary industry share causes a net increase of 0.0759% (0.5700 - 0.4941) in per capita emission which is 0.05 times smaller than the one estimated in simultaneous equation.

Discussion for the remaining variables in Equation (1); It shows that when there is a 1% increase in the number of motor vehicles used per capita emission for PM_{10} will increase by 0.7002% only. Using the single polynomial equation, the coefficient of motor vehicles turns to be lower in PM_{10}. In the case of per capita emission for SO_2 it does not follow the theory as 1% increases in the number of motor vehicles used per capita emission for SO_2 will decrease by 0.3288%.

For population density, it shows that as a one percent increase in population density, per capita pollution emission for SO_2 will decrease by 5.6719%, per capita pollution emission for PM_{10} will decrease by 2.1758% and per capita pollution emission for O will decrease by 14.7214%. Using the single polynomial equation, the coefficient of population density turns to be lower and it shows that population density increases pollution emissions which will reduce less compared to simultaneous polynomial equation. This indicates that the people are not aware of pollution.

Simultaneous equation model

(a) The estimated results suggest that in all pollutants except CO the expected EKCs are found to exist.

The differences between these two methods are found in the estimated coefficients of several other explanatory variables.

(i) Per capita pollution abatement expense elasticity's in the case of CO on per capita emission turns to be negative in relationship as per capita pollution abatement expense increases by one percent per capita emission of CO decreases by 0.3298 percent due to the two stages least square method. Similarly to NO in which as per capita pollution abatement expense increases by 1 percent per capita emission of NO decreases by 0.8706. This follows the economic theory that as per capita abatement expense increases, per capita emissions decrease.

(ii) Using the two stage least square method CO decreases by 0.3298 percent and NO decreases by 0.8706 when there is an increase by one percent per capita emission. This evidence is significant to give the policy makers a higher incentive to invest more on pollution abatement in order to reduce pollutant emissions.

(iii) As can be seen in Table 2, by using the simultaneous equation in air pollutants for SO_2 and PM_{10}, the turning points, $-\alpha_1/2\alpha_2$ of these inverse-U-shaped curves are estimated nearly 0.89 times, 0.43 times, smaller in magnitude after applying the two stage least square method. This evidence indicates that the turning points would be overestimated if this study estimates the impact of income on pollution directly by a single polynomial equation model and ignores the simultaneous relationship between income and pollution. It shows that a different policy implication has been implemented by the central government of Malaysia. The result indicates that after the per capita GDP reaches upper level, in the case of PM_{10}, the per capita emission should be decreased as income increases provided if this study believes that there is no simultaneity between income and pollution. Being different from the simultaneous equations model, the per capita emission starts to decrease after the per capita GDP reaches the lower level. These changes caused by different estimation methods may correspond to different economical and environmental policies implemented by the central government of Malaysia. As reported by UNDP (1997), Malaysia's record on the protection of the environment is generally satisfactory, as it has one of the least polluted urban environments in Asia. This is due to the Government implementing a number of measures to ensure that productivity and economic growth are not compromised by serious environmental problems. The Seventh Plan calls for existing programs and priorities to be extended to conserving critical environments, raising environmental awareness and promoting better management of natural resources, so that development is sustainable and balanced. Environmental conservation considerations will therefore increasingly be integrated with development planning. For example, Malaysia has made a number of international environmental commitments and is translating them into national action. In the context of the national environment policy, the Seventh Plan identifies a range of policies, strategies and program thrusts to improve environmental management. This includes firstly, capacitybuilding in the Government at the federal and state levels in key areas of environmental management. Secondly, is allowing the development training modules for training institutions to enhance environment planning, monitoring and enforcement, as well as to better integrate the approaches and efforts of the Government, the private sector and the civil society. Thirdly, it is following a national workshop on Grant Funding in Malaysia in 1996, such as the wetland conservation, energy conservation, land biodiversity, coastal management and finally continuing and completing the Montreal Protocol programs, so as to meet the target set for the phasing-out of ozone-depleting substances by 2002. Due to the above discussion, it shows that pollution has been successfully controlled by Malaysia earlier than the stage of single equation.

(iv) To investigate industrial structural impact by two sources:

(1) Direct impact measured by the coefficient in Equation (1):

In the case of NO, the direct impact indicates that a 1% increase in the secondary industry share causes an increase of 2.0301% in per capita emission in Table 4.

(2) Indirect impact measured by the coefficient of the secondary industry share in Equation (3) multiplying the coefficient of per capita pollution abatement expense in Equation (1):

In the case of NO, the indirect impact via pollution abatement expense shows that a 1% increase in the secondary industry share causes a decrease of 4.4877% of per capita pollution abatement expense in Table 6, and a 1% increase in pollution abatement expense increases per capita emission by 0.1265% in Table 4, therefore, an decrease of 0.5677 % (4.4877*0.1265) of per capita emission.

(3) Net impact should be calculated as the net values of these two impacts:

In the case of NO, the net impact is that a 1% increase in the secondary industry share causes a net increase of 1.4624% (2.0301 - 0.5677) in per capita emission which is 19.3 times larger than that one estimated in single polynomial equation. This result shows that secondary industry share is one of the main contributors of pollutants in Malaysia. This is true as Malaysia has undergone a major structural transformation moving from agriculture to manufacturing-based economy. Increasing transportation activities arising from rapid industrial growth and urbanisation are the main contributing factors to the persistently prevailing problem of air pollution in the world today (Mahathir, 1996). Industrial zone such as Shah Alam in Malaysia is now one of the most highly polluted areas in the country.

Discussion for the remaining variables in Equation (1); by applying the two stages least square method, the coefficients of motor vehicles turn to be higher in PM_{10}. It shows that when a 1% increase in the number of motor vehicles used per capita emission will increase by 23.742%. In the case of per capita emission of SO_2, it shows that when a 1% increase in the number of motor vehicles used per capita emission of SO_2 will increase by 15.836%.This indicates that other main sources of pollution in Malaysia come from transportation.

For population density, it shows that as one percent increase in population density, per capita pollution emission for SO_2 will decrease by 34.403%. The per capita pollution emission for PM_{10} will decrease by 42.824% and per capita pollution emission for O will decrease by 42.4565%. Using the simultaneous equation, the coefficient of population density turns to be higher and it shows that as population density increases pollution emissions is reduced more compare to single polynomial equation. This indicates that the people are very aware of pollution.

Based on the estimated results of income and abatement equations in Table 5 to Table 6, most of the estimated coefficients are significant and consistent with the expected signs. In the income equation, physical capital and foreign labor majority contribute positively to the Gross Domestic Product. On the other hand, local labor majority contribute negatively to the Gross Domestic Product in the equation. This indicates that foreign labor is one of the determinants of economic growth in Malaysia compared to local labor. The contribution of human capital in production is not significant in the model although labor is an important factor in production. This indicates that the economic development in Malaysia relies primarily on capital-intensive industries. The evidence can be seen in income equation, in which there is a positive significant relationship between physical capitals per capita with economic growth. The two indicators of pollutant emissions, PM_{10} and NO_2 are negatively related to the GDP and one measure, NO_2 showing significance on income. This is consistent with the theory that as pollution level increases income decreases. Thus, this study can conclude that there is a small significant feedback of air pollutants on income in Malaysia as NO_2 is the indicator that shows significant feedback.

Besides these, the coefficients of government expenditure are positive and all are highly significant. This indicates that government spending has contributed as one of the main determinants of economic growth in Malaysia. Foreign direct investment also has a positive significant effect on income. Again it shows that foreign direct investment is one of the determinants that increase the economic growth in Malaysia. Meanwhile, most of the coefficients of university graduates positively and significantly contribute to economic growth in Malaysia. The secondary industry share and the physical capital are the two critical determinants of the pollution abatement expense. The result from this study shows that it follows the theory that there is a positive significant relationship between secondary industry share and pollution abatement expense. It can be seen that most of the coefficients of physical capital have a positive relationship with pollution abatement expense. This indicates that the higher the physical capital is the higher the pollution abatement expenses are. Due to this, to keep sustainable growth in the long run for the Malaysian economy, more pollution abatement investments are required even though pollution is not the main contributor that reduces income in Malaysia. Turning to the fourth equation that is population density equation, most of the coefficients of air pollution indicators show significantly on population and all of it having a negative relationship except for PM_{10}. This indicates that as pollution emission increases, population density reduces in Malaysia.

CONCLUSIONS

From previous literature, the economy and its environment are jointly determined. As a first step towards better understanding of the income-environment relationship, this study incorporates explicitly the simultaneity between income and pollution. By using the existing theoretical framework, this study uses the theory that economic growth and pollution are jointly determined. According to Shen (2006), if simultaneity between income and pollution does exist, investigating the relationship between these two variables only by a commonly used single polynomial equation produces biased and inconsistent estimates. Several different results between a single polynomial equation model and a simultaneous equations model have been found by this study. This issue indicates that in future EKC studies, the necessity of investigating the simultaneity between income and pollution should be considered. Therefore, before regressing the model, there is a necessity to test for simultaneity. In some of the indicators emissions in Malaysia the EKC relationship is found.

Some conclusions can be drawn by this study. Firstly, in Malaysia there exists a pattern of "pollute first and control pollution later" since the EKC hypothesis is supported in the cases of some indicators of pollutant. It has been rather uneven by the government to protect the environment towards enforcement and implementation of policies. According to Petra (2006), the per capita greenhouse gas emission of Malaysia is rising. This indicates that governments do not seriously enforce regulations to abate pollution. Government also put economic growth and industrial production first. Secondly, at an earlier stage of economic development the turning points of EKC occurred. A study by O'Connor (1994) states that there may be four reasons for the "latecomer's advantage" such as increased availability of technology, learning from experience, increased exposure to international environmental pressures and lower unit abatement costs. It can be said that Malaysia has this advantage based on the timing of these turning points. This is true as supported by GTZ (2006) claims that activities at the international level is based on European standards which include private sector technology transfer between Malaysia and Europe and promotion of the Clean Air Initiative for Asian Cities. This indicates that especially on environmental, part of the Malaysian regulations have been built upon foreign countries' experiences. The lowering of the peak in the environmental Kuznets curve also resulted from the effects of the central government's environmental policies.

Most of the indicators of air pollutants, the government pollution abatement expense has a negative insignificant effect on it. This implies that environmental policy is not strong in Malaysia. Due to this in order to reduce pollution government should stringent and tighten the policy. There are all positive net impacts on per capita pollutant emission from the secondary industry share. This indicates that in determining pollution, an important role has been played by the industrial structure. In the Model, it exhibits negative significant effects on SO_2 by population density. Since SO_2 is mainly comes from industrial activities, they are most probably the first one to be controlled. According to the Department Of Environment Malaysia (2005), high concentrations of SO_2 in the atmosphere irritate the respiratory system. It can increase the risk of adverse symptoms in asthmatic patients. Between 1996 and 2004 the annual average levels of SO_2 in the ambient air were well below the Malaysian Ambient Air Quality Guideline. This implies that there is a negative impact on air pollutants as population density increase. This study concludes that population density and industrial structure have important effects on pollution in Malaysia. Besides, consistent with the expectation most of the estimated coefficients in income equations, abatement equations and population density equations are significant. This study put a recommendation for a future studies to include variables such as solid waste treatment, hazardous waste and noise in the city. These variables are all important to residents as the environment exerts an all-round influence apart from air pollution and water quality. Apart of it, factors such as GINI index of income distribution can be taken into account to measure the equality of income distribution in Malaysia. Therefore, in any of these directions a further extension could be made.

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